The functional relevance of neurological recovery after lumbar discectomy

A FOLLOW-UP OF MORE THAN 20 YEARS

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We have studied 180 patients (128 men and 52 women) who had undergone lumbar discectomy at a mean of 25.4 years (20 to 32) after operation. Pre-operatively, most patients (70 patients; 38.9%) had abnormal reflexes and/or muscle weakness in the leg (96 patients; 53.3%). At follow-up 42 patients (60%) with abnormal reflexes pre-operatively had fully recovered and 72 (75%) with pre-operative muscle impairment had normal muscle strength. When we looked at patient-reported outcomes, we found that the Short form-36 summary scores were similar to the aged-matched normative values. No disability or minimum disability on the Oswestry disability index was reported by 136 patients (75.6%), and 162 (90%) were satisfied with their operation. The most important predictors of patients' self-reported positive outcome were male gender and higher educational level. No association was detected between muscle recovery and outcome.

Most patients who had undergone lumbar discectomy had long-lasting neurological recovery. If the motor deficit persists after operation, patients can still expect a long-term satisfactory outcome, provided that they have relief from pain immediately after surgery.

The presence of a neurological deficit is a strong indication for surgery in patients with lumbar disc herniation,[1,2] and motor and sensory improvements can often be expected after discectomy.[3] Post-operative neurological improvement has been traditionally used to assess the long-term results of discectomy.[4,5] Recently, patient-reported outcomes have gained importance in this evaluation.[6] Previous studies have provided conflicting evidence on the short- and medium-term relationship between neurological recovery and the self-reported outcome of patients who had undergone surgery for lumbar disc herniation,[3,6-9] but there is a lack of long-term follow-up data. We have evaluated the long-term neurological status after lumbar discectomy at a minimum of 20 years to ascertain whether the recovery obtained is related to the patient-reported outcome.

Patients and Methods

Between 1973 and 1982, 409 consecutive patients had a standard discectomy for lumbar disc herniation at our institution. The inclusion criteria were severe sciatica of at least eight weeks duration which was unresponsive to conservative treatment, and/or signs of motor deficit. We excluded 18 patients with complete paralysis who lacked any visible or palpable muscle contraction or those with a cauda equina syndrome. A further 70 patients (18%) had died and 141 were lost to follow-up. Thus, we enrolled 180 patients (128 men and 52 women) into the study. They represented 56% of the surviving patients. No significant differences were found between the participants and the patients lost to follow-up with respect to age, age at operation, gender, the level of discectomy, or the neurological deficit. The mean follow-up was for 25.4 years (20 to 32) and the mean age at follow-up was 62.8 years (37 to 83). The diagnosis of lumbar disc herniation and its level were assessed clinically. The operation involved a standardised technique with a laminotomy and fenestration followed by herniotomy and curettage of the disc space. One-level discectomy was carried out in 152 patients (84.4%) and at two levels in 28 (15.6%). Discectomy was carried out at L5-S1 in 78 cases, L4-5 in 118 and L3-4 in 12, accounting for both single- and double-level surgery.

The pre-operative and early post-operative data were obtained from a proforma which documented the clinical history and physical findings. From it we extracted details of the age at operation, educational level, pre-operative duration of leg pain and the relief from low back and leg pain reported by the patients on

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the fifth day after operation. The restriction in the straight leg raising test, the power of extensor hallucis longus and the gastrocnemius-soleus muscle, and the ankle and knee reflexes were recorded for each patient. The power of the extensor hallucis longus, which is mainly innervated by the L5 nerve root, was tested on the supine patient, with the examiner resisting active dorsiflexion of the hallux whilst comparing the muscle strength with the contralateral side. The ability to stand on tiptoe was used to test the calf muscles, mainly innervated by the S1 nerve root. According to our protocol, weakness of the gastrocnemius-soleus is present when the patient is completely or partially unable to rise on tiptoe while standing on a single leg such that the heel is elevated ≤ 2 cm from the ground.

At follow-up, the patients gave their informed consent and underwent a physical and neurological examination. The clinical investigation was carried out by one of the authors (VS) not involved in the primary care, who was unaware of the pre-operative findings, functional status, or the level of satisfaction of the patient. In order to keep the method of evaluation as comparable as possible to the pre-operative examination and to match a previous study,[8] the independent examiner was trained prior to starting the study by the senior author (CM), who had carried out most of the pre-operative examinations, by performing combined examinations in 15 patients with lumbar disc herniation who were not involved in the study.

The following patient-based questionnaires were chosen: the official Italian version of the Short Form-36 Health Survey (SF-36) to evaluate the generic health-related quality of life,[10] the Oswestry disability index which is considered to be a disease-specific tool,[11] the cumulative illness rating scale which is a validated tool to assess the burden of co-existing chronic illnesses,[12,13] and a study-specific questionnaire designed to record data on possible re-operations and to assess the satisfaction with surgery and willingness to undergo the same operation again. The SF-36 survey contains 36 questions measuring physical, social, and mental components. Following Sun et al,[14] a difference of ten or more points between the score in the study group and the normative score on the SF-36 scales was considered a significant variation. The final results of the Oswestry disability index were categorised into groups of increasing functional impairment as follows: 0% to 20% (minimal disability); 20% to 40% (moderate disability); and ≥ 41% (severe disability).[15] A total of 15 randomly-selected patients completed the questionnaires twice, with a ten-day interval to assess test-retest reliability. Pearson's product-moment correlation coefficients for the results of the tests ranged from 0.73 to 0.90 for the SF-36 scale scores, averaged 0.82 for the Oswestry disability index and 0.90 for the cumulative illness rating scale. These results are in keeping with published standards for both the SF-36 scale scores[10] and the Oswestry disability index.[16]

Statistical analysis. A two-sample *t*-test, chi-squared test, and Fisher's exact test were used to test the significance of the cross-sectional differences between the groups. Pearson's correlation coefficient was used to assess the relationships among patient-oriented outcomes. Models of multiple stepwise linear and logistic regression analysis were constructed to evaluate the relationships between the explanatory variables, and the outcomes with continuous and categorical distributions, respectively. Two variables were created to express the variation observed at follow-up of the muscle strength and tendon reflexes, respectively, with respect to the pre-operative data. The results for each patient were divided into two categories for both tendon reflexes and muscle strength; those that improved from a pre-operatively abnormal reflex or impaired muscle power to be normal at follow-up, or those which were unchanged or had deteriorated. Possible determinants of the improvement were then checked by multivariate analysis. The influence of neurological improvement on the patient-reported outcome was also evaluated. For this purpose patients with a disturbance in the pre-operative tendon reflex or muscle weakness were inserted into separate models of multivariate analysis and the influence of their neurological recovery on the outcomes of interest was checked. The physical and mental component summary scores of the SF-36, the SF-36 single subscales scores, and the Oswestry disability index were treated as continuous outcome variables, whereas the satisfaction with surgery and the willingness to undergo the operation again were categorical outcome variables. Besides the neurological recovery, the explanatory variables included in the multivariate analysis were present age, gender, age at operation, educational level, pre-operative duration of leg pain, immediate post-operative relief from back pain, immediate post-operative relief from leg pain, re-operation, and the cumulative illness rating score. The pre-operative duration of the leg pain was summarised on a four-point scale: 1) two to three months, 2) four to six months, 3) seven to 12 months, and 4) more than 12 months. The educational level was graded as illiterate, primary school, secondary school, high school, and graduate. A value of $p < 0.05$ was considered significant. The SPSS software program (SPSS Inc., Chicago, Illinois) was used for the database and statistics.

Results

Pre-operative and early post-operative data. The baseline characteristics of the study group are shown in Table I. The mean pre-operative duration of leg pain was for 18 months (2 to 96). Straight leg raising test was restricted by pain in 160 patients (88.9%). Abnormal reflexes were present pre-operatively in 70 patients (38.9%) with absent or decreased knee and ankle reflexes found in four (2.2%) and 70 (38.9%), respectively (four patients had both knee and ankle abnormal reflexes). Muscle weakness was reported in 96 patients (53.3%) pre-operatively, involving extensor hallucis longus patients in 86 patients (47.8%) and the gastrocnemius-soleus in 16 (8.9%). Ten patients had weakness in both muscles. A total of 103 patients (57%) reported a

Table I. Details of the patients

Mean age at operation (range)	36.8 (18 to 57)
Gender	
Male (%)	128 (*71.1*)
Female (%)	52 (*28.9*)
Educational level (%)	
Illiterate	12 (*6.7*)
Attended primary school	56 (*31.1*)
Attended secondary school	62 (*34.4*)
Attended high school	46 (*25.6*)
Graduated	4 (*2.2*)
Duration of pre-operative leg pain (mths) (%)	
2 to 3	58 (*32.2*)
4 to 6	45 (*25.0*)
7 to 12	17 (*9.5*)
> 12	60 (*33.3*)

pre-operative duration of sciatica of less than six months and they were more likely to have painful restriction of straight leg raising (chi-squared test, $p = 0.002$). There was no relationship between the presence of abnormal pre-operative reflexes and the duration of symptoms. There was no significant relationship between pre-operative muscle weakness or abnormal reflexes and the age or gender of the patient. Total relief from sciatica and back pain on the fifth day after operation was reported by 150 (83.3%) and 136 (75.6%) patients, respectively. Early relief from pain was significantly associated with being male (chi-squared test, $p < 0.001$), but not the age at operation or the pre-operative duration of leg pain.

Follow-up data. A re-operation was required in 28 patients (15.6%). The straight leg raising test was pain-free in 146 of the 160 patients (91.2%) who had a painful restricted test before operation. Of the 70 patients with abnormal reflexes before operation, 42 (60%) had normal reflexes at follow-up. The ankle reflex recovered in 44 patients (62.9%), and the knee reflex in all cases. No gender difference was observed in the rate of recovery of these reflexes. In 24 of 110 patients (21.8%) with normal reflexes pre-operatively, reduced or absent reflexes were found at follow-up, affecting the knee in four patients and the ankle in 20. These changes were seen more frequently in patients who had undergone a re-operation (chi-squared test, $p < 0.001$). In total, 72 of the 96 patients (75%) with pre-operative muscle impairment had normal muscle strength at follow-up. Recovery of the extensor hallucis longus and gastrocnemius-soleus was seen in 70 of 86 patients (81.4%) and 12 of 16 patients (75%), respectively. Men and women had similar rates of muscle recovery. The pre-operative duration of leg pain was not significantly different in the patients with post-operative motor recovery (mean 15.6 months, 2 to 60) compared with those with persisting post-operative muscle weakness (mean 13.7 months, 2 to 65). Impairment in the function of the extensor hallucis longus was seen at follow-up in eight patients in whom the power was considered normal when first seen. This occurred more frequently in patients who had further surgery (chi-squared test, $p = 0.039$). There was no correlation between recovery of the reflexes and improvement in muscle strength at the time of follow-up.

The mean SF-36 physical component summary and mental component summary scores were 43.5 (14 to 60) and 46.4 (22 to 64), respectively. Both were similar to normal values for Italian people in the comparable age group, at a mean of 47.7 (SD 9) and 45.4 (SD 10).[17] The single SF-36 scale scores are shown in Table II and are compared with their age- and gender-matched controls.[17] While the scores of the men were similar to the normal data, the women compared poorly with healthy controls, except for the vitality and mental health scales. The mean Oswestry disability index was 15.7 (0 to 86). No or minimal disability was reported by 136 patients (75.6%), moderate impairment by 16 (8.8%), and severe disability by 28 (15.6%). The mean Oswestry disability index was 10.6 (0 to 86) in men and 28.3 (0 to 78) in women (two-sample *t*-test, $p < 0.001$). The responses for the study-specific questionnaire for the whole study group and divided by gender are shown in Table III. Women had significantly lower levels of satisfaction with their care than men; they also had undergone re-operation more frequently. With the numbers available, the SF-36 physical component summary and mental component summary scores, the Oswestry disability index, and the level of satisfaction were not significantly different in patients who recovered their muscle power compared with those who did not. There were significant correlations between the Oswestry disability index and the physical component summary scores ($r = -0.76$; $p < 0.001$), between the physical and mental component summary scores ($r = 0.46$; $p < 0.001$) and between the Oswestry disability index and the mental component summary scores ($r = -0.57$; $p < 0.001$).

Regression analysis. When several possible predictors for the improvement of tendon reflexes at follow-up in patients with abnormal pre-operative reflexes were studied using multivariate stepwise logistic regression analysis, the age at operation was the only factor negatively associated with this outcome (odds ratio (OR) = 0.80, 95% confidence interval (CI) 0.62 to 0.92, $p = 0.002$). Subjects with higher cumulative illness rating scores had less recovery of muscle strength at follow-up (OR = 0.83, 95% CI 0.74 to 0.94, $p = 0.003$), whereas early post-operative relief from leg pain was a weak positive predictor of this recovery (OR = 4.04, 95% CI 1.06 to 15.37, $p = 0.040$).

Determinants of the SF-36 summary scores and the Oswestry disability index using multiple linear regression analysis are shown in Table IV. In patients with pre-operative muscle weakness only, several predictors of outcome were identified, but there was a lack of association between muscle recovery at follow-up and all the outcomes. The strongest positive predictors were male gender and a higher educational level. In patients with abnormal pre-

Table II. Mean (SD) Short Form (SF)-36 scores in men and women with age- and gender-matched controls[17]

	Men		Women	
SF-36 scale	**Patients**	**Controls**	**Patients**	**Controls**
Physical functioning	82.1 (24)	83.8 (20)	48.3 (34)	74.8 (24)
Role physical	68.8 (40)	72.5 (33)	35.6 (42)	72.6 (36)
Bodily pain	68.8 (28)	73.6 (24)	41.6 (25)	63.5 (27)
General health	61.6 (18)	61.7 (19)	36.3 (24)	58.6 (22)
Vitality	63.5 (18)	63.9 (19)	44.4 (17)	54.1 (21)
Social functioning	80.1 (24)	78.4 (23)	55.8 (30)	74.5 (22)
Role emotional	72.9 (39)	73.6 (34)	41.0 (42)	66.1 (40)
Mental health	69.7 (17)	69.4 (18)	53.8 (16)	57.6 (21)

Table III. Patients' satisfaction with care and re-operations

	All patients		Men		Women		
	Yes (%)	**No (%)**	**Yes (%)**	**No (%)**	**Yes (%)**	**No (%)**	**p-value***
Satisfaction with the surgery	162 (*90*)	18 (*10*)	124 (*97*)	4 (*3*)	38 (*73*)	14 (*27*)	< 0.001
Willingness to undergo the operation again	162 (*90*)	18 (*10*)	120 (*94*)	8 (*6*)	42 (*81*)	10 (*19*)	0.012
Re-operations	28 (*16*)	152 (*84*)	12 (*9*)	116 (*91*)	16 (*31*)	36 (*69*)	0.001

* chi-squared test

operative reflexes only, the cumulative illness rating score was inversely related to the physical and mental component summary scores, and directly related to the Oswestry disability index. Improvement in the reflexes at follow-up also predicted a better self-reported quality of life and function, but explained little of the variance. In these models, a higher educational level also predicted a higher physical component summary and a lower Oswestry disability index score. When single SF-36 subscale scores were used as outcome variables, no significant positive role of muscle improvement at follow-up emerged from multivariate analysis. Conversely, improvement in the tendon reflexes predicted higher scores on the physical functioning, role physical, bodily pain, general health, mental health, and social functioning subscales, accounting on average for 9.5% of the variance.

The determinants of patients' satisfaction with their care when assessed by multivariate stepwise logistic regression analysis are shown in Table V. Neither muscle or reflex improvement at follow-up were associated with self-reported outcome. A higher educational level positively predicted both satisfaction and willingness to undergo the same operation again in subjects with pre-operative muscle weakness.

Discussion

The rates of recovery of motor deficits and disturbances in tendon reflexes in our patients after a minimum of 20 years after lumbar discectomy were 75% and 60%, respectively. These figures fall within the range of results of previous studies with shorter periods of follow-up.[3,8,18] As there were no comparative data on patients who did not undergo surgical treatment, we cannot be sure that the discectomy was responsible for the neurological recovery. Indeed, herniation of a lumbar disc shows a favourable response to conservative treatment,[19] even in the presence of neurological deficit.[20] The recovery of the tendon reflexes and improvement in muscle weakness in our patients was sustained over time, but it did not influence the long-term self-reported quality of life or functional status of patients. Traditionally, much importance has been attached to neurological deficit as an indication for surgical treatment in patients with lumbar disc herniation, but no data has been published on the functional relevance of the neurological recovery more than 20 years after surgery. Some previous studies have reported good correlations between surgeon- and patient-based outcome measures within five years of the operation,[3,6,7] even though a neurological deficit may persist in patients who are satisfied because their pain disappeared after surgery.[3] Other authors failed to find a strong relationship,[8,9] and Vucetic et al[21] concluded that the overall outcome of discectomy is influenced to a lesser extent by neurological signs than by psychosocial aspects or pain, which are more important determinants. The lack of a correlation between long-term neurological recovery and quality of life and functioning in our patients is primarily attributable to the long period which elapsed between the operation and the follow-up, since the patient's self-analysis can differ more from the evaluation of the surgeon as time passes.[7] The longer the follow-up, the less important is the influence of neurological recovery on the patient's assessment of their quality of life. According to our standardised protocol, we tested the strength of the extensor hallucis longus and gastrocnemius-soleus to assess the involvement of the L5 and S1 nerve roots, respectively. The same

Table IV. Determinants of the short form (SF)-36 health survey and the Oswestry disability index at multiple linear regression analysis

	Outcome				
Explanatory variable	**r***	**95% confidence interval**	**p-value**	**Total adjusted R^2 (%)**	**R^2 change (%)**
Patients with pre-operative muscle weakness (n = 96)					
SF-36 physical component summary					
Male gender	8.10	3.6 to 12.6	0.001	*28*	*28*
Educational level	5.50	2.5 to 7.5	< 0.001	*53*	*25*
Immediate post-operative relief from back pain	7.82	3.3 to 12.3	0.001	*59*	*6*
Cumulative illness rating score	-0.59	-1.0 to -0.2	0.007	*63*	*4*
SF-36 mental component summary					
Male gender	8.18	3.5 to 12.9	0.001	*19*	*19*
Age	-0.38	-0.75 to -0.01	0.042	*23*	*4*
Oswestry disability index					
Educational level	-8.08	-12.28 to -3.88	< 0.001	*24*	*24*
Age	0.80	0.12 to 1.49	0.022	*37*	*13*
Immediate post-operative relief from leg pain	-16.84	-26.84 to -6.83	0.001	*44*	*7*
Cumulative illness rating score	1.00	0.12 to 1.87	0.026	*47*	*3*
Patients with pre-operative reflex disturbances (n = 70)					
SF-36 physical component summary					
Cumulative illness rating score	-0.97	-1.29 to -0.65	< 0.001	*40*	*40*
Male gender	9.39	5.15 to 13.63	< 0.001	*55*	*15*
Educational level	3.99	1.93 to 6.05	< 0.001	*67*	*12*
Reflex improvement	6.73	2.85 to 10.60	0.001	*72*	*5*
Pre-operative duration of symptoms	-1.61	-2.92 to -0.30	0.017	*75*	*3*
SF-36 mental component summary					
Cumulative illness rating score	-1.03	-1.35 to -0.71	< 0.001	*37*	*37*
Reflex improvement	6.09	1.71 to 10.47	0.007	*45*	*8*
Oswestry disability index					
Cumulative illness rating score	2.10	1.40 to -2.81	< 0.001	*29*	*29*
Educational level	-13.32	-18.26 to -8.38	< 0.001	*53*	*24*
Reflex improvement	-11.76	-21.23 to -2.29	0.016	*58*	*5*

* r, coefficient

Table V. Determinants of patients' opinion of their surgery at multivariate stepwise logistic regression analysis

Explanatory variables	**Odds ratio**	**95% confidence interval**	**p-value**	**-2 log likelihood ratio (deviance)**	**p-value of log likelihood ratio**
Patients with pre-operative muscle weakness (n = 96)					
Satisfaction					
Educational level	9.80	2.15 to 44.8	0.003	21.3	< 0.001
Patients with pre-operative reflex disturbances (n = 70)					
Satisfaction					
Cumulative illness rating score	0.83	0.69 to 0.99	0.049	7.69	0.006
Re-operation	0.10	0.01 to 0.96	0.046	5.23	0.022
Willingness to undergo the operation again					
Educational level	14.19	2.08 to 96.73	0.007	26.47	< 0.001

muscles have been tested in previous studies[3,8,9] and the manual testing of extensor hallucis longus is the most useful screening test for impairment of the L5 nerve root.[22] However, the selection of these muscles might have contributed to the lack of an association with the long-term patient-reported outcome detected in our study. Indeed, while the impairment of pelvic stabilisers has a negative predictive role, the post-operative impairment of distal motor function in the leg muscles has been shown to be unrelated to post-operative pain and disability.[9] We chose to exclude patients with complete pre-operative myotomal paralysis, although the outcome in this group would have been of great interest. The aim of the study was to ascertain whether the neurological recovery obtained with surgery was related to the outcome rather than to assess the possible effect of severe residual motor deficits on the long-term

function and quality of life. Indeed, previous clinical and electrophysiological studies[8,23] have shown that patients with complete paralysis are less likely to obtain recovery after operation and such patients have also been excluded from studies with a shorter follow-up.[8]

Most of our patients, particularly the men, reported high levels of satisfaction with long-term quality of life, functional ability, and self-reported post-surgical satisfaction. It is unclear how much of their quality of life and function can be attributed to the surgery, but these outcomes were mainly determined by factors independent of their neurological recovery, and many were identified on the multivariate analysis. Male gender and higher educational level were major positive determinants, while the number of comorbidities (the cumulative illness rating score) was negatively related to outcome. In this study, the scores for women were worse than those recorded in healthy subjects on the SF-36 and women also reported lower levels of satisfaction after the operation and higher levels of disability than men. We and others have reported similar findings.[15,21,24-27] This gender difference is likely to be secondary to factors independent of the operation, since postmenopausal women may be prone to report chronic complaints.[27] Higher educational level also has been shown to be a reliable predictor of a good outcome following lumbar discectomy in previous studies with different periods of follow-up.[15,21,28,29] In our patients with pre-operative muscle weakness, the early relief from pain was positively related to the physical component summary score and inversely related to the Oswestry disability index scores. This confirms previous findings[25,26,30] indicating that early residual symptoms following lumbar discectomy are associated with poor recovery and with residual leg and back pain at short- and long-term follow-up.

The long-term recovery of tendon reflexes and muscle strength in our study were negatively associated with older age at operation and the extent of any comorbidity, respectively, regardless of the patient's gender. Previous studies have also reported a negative correlation between age and motor recovery in different lumbar conditions,[23,31] and other studies have shown a negative correlation with a long pre-operative duration of symptoms.[3,8] Both these results might reflect impairment in the nerve root regeneration related either to age or longstanding nerve compression.

We acknowledge some limitations of this study. The retrospective design is a limitation, but performing a prospective analysis with such a long follow-up would be almost impossible. There may have been some variability in information gathering at the time the patients were treated. Indeed, the pre-operative evaluation was done by different doctors and this is inevitable in a retrospective analysis of patients undergoing surgical treatment over a period of ten years. However, the pre-operative information obtained from the medical records consisted primarily of unambiguous data and we adopted two strategies to further reduce this possible bias. We used only the pre-operative and early post-operative data included in the forms that have been used in our department throughout, and we dichotomised the variables used in the analysis to indicate both the pre-operative muscle strength and the status of the tendon reflexes (as normal or abnormal) and their change during the period of follow-up (as improved or unchanged/deteriorated). We chose to exclude any data which were entered at intermediate follow-up because of their questionable reliability. This choice prevented us from evaluating possible variations in the patients' neurological and subjective status over the period of follow-up. In addition, even though most participants reported positive long-term self-reported outcomes, we cannot exclude that the severity of the back pain of some patients at follow-up influenced their answers on the SF-36 and Oswestry disability index. However, the study was conceived only to assess the influence of neurological status after lumbar discectomy on the present quality of life and function. Although we attempted to trace all the patients, this was impossible due to the long time that had elapsed since the surgery. However, our survey rate is similar to other studies with a shorter follow-up[18] and this has been deemed adequate for other long-term follow-up studies.[32] The characteristics of the patients enrolled were similar to those lost to follow-up, and our study group can be considered representative of the entire population. The main strength of this study is the length of follow-up, and the use of validated tools should have ensured a reliable assessment of quality of life and function with numerical scores used for the regression analysis.

Our study mainly reflects the late results of lumbar discectomy and perhaps operative treatment is only one event in the 25-year history of these patients. However, one recent prospective study has indicated that patients undergoing lumbar discectomy are not fully satisfied with the information they are given before surgery, and that their two-year self-reported outcome is positively influenced by high pre-operative expectations with respect to reduction in pain and return to work.[6] The main implication of our study is that patients scheduled for lumbar discectomy are likely to obtain a long-lasting neurological recovery. Should the neurological deficit persist after surgery, they can still expect a good long-term outcome, provided that they had immediate post-operative relief from pain.

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